BANA 4090: Chapter 5: (Part I)

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- Main topics:
  - HW # 4
  - Exponential smoothing

HW # 4

Forecast errors

- Forecast "error": the difference between an observed value and its forecast:
    - $e_{T+h} = y_{T+h} - \hat{y}_{T+h|T}$,where the training data is given by $\{y_1, ..., y_T\}$.
- R Lab Notes (**selecting values from a matrix in R**).

Exponential smoothing

Exponential smoothing

- **What it is?**
- **Exponential smoothing methods are**...
  - weighted averages of past observations, with the weights decaying exponentially as the observations get older.

Types of exponential smoothing

- What are the 3 main types of exponential smoothing?
  - **Simple exponential smoothing**: for series with no trend or seasonality.
  - **Holt's method**: with trend, no seasonality.
  - **Holt-Winter's method**: with trend & seasonality.

Exponential smoothing

Big picture

- Forecast future values using a **weighted average** of all previous values in the series.
- Advantages:
  - **flexible**,
  - **computationally efficient**,
  - **good performance, ease of automation**,
  - **ease of automation**.

A specifical case: Moving average

- **The idea**: Compute value based on average of several observed values.
- **Uses**: Visualization, Forecasting, Computing seasonal indices.
- **Advantages**: Simple, intuitive, popular, data-driven.
- **Key concept**: Width of window.
- **Trailing moving average(trailing MA)**: based on a window from time t and backwards. In R, `ma()` function.
    - To forecast a series at time t+k, use a trailing MA that ends at time t.

Data Example

- Using the `Natural Gas Sales.xls` data:
    - Identify the preferred window length for moving average
    - Compute and plot a centered moving average
    - Remove the last observation (Fall - 2004) and use a trailing MA to predict for Fall - 2004
    - How does this prediction compare to a seasonal naive estimate?

Data Example (cont'd)

- Import data:

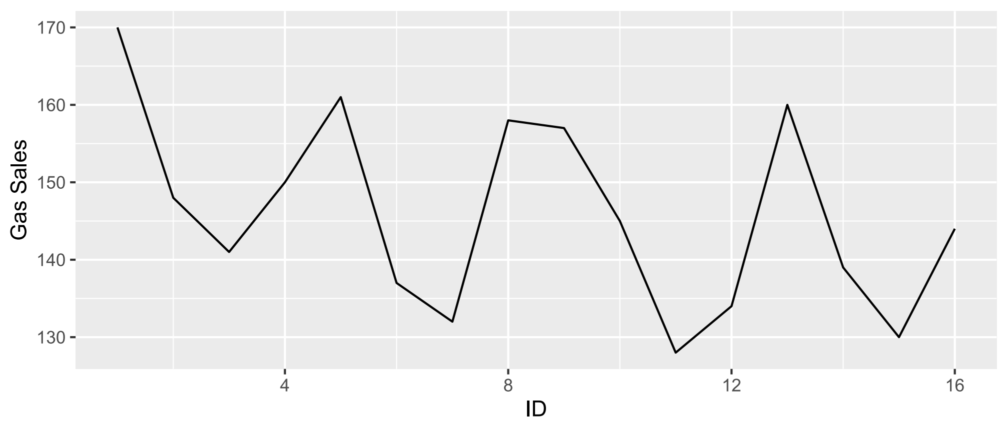
```
setwd("C:/Users/fanzh/OneDrive - University of Cincinnati/UC_couse/000_Teaching_4090_S
gas <- read_excel("Natural Gas Sales.xls",
                  col_types = c("text", "numeric", "skip", "skip"))
head(gas,8)
```

```
## # A tibble: 8 x 2
##   Quarter     `Gas Sales`
##   <chr>             <dbl>
## 1 Winter-2001         170
## 2 Spring-2001         148
## 3 Summer-2001         141
## 4 Fall-2001           150
## 5 Winter-2002         161
## 6 Spring-2002         137
## 7 Summer-2002         132
## 8 Fall-2002           158
```

Data Example (cont'd)

- Plot so that we can identify preferred window length.
- Seasonality appears to follow the quarters so an appropriate window length would be 4.

```
gas %>%
  mutate(ID = 1:nrow(gas)) %>%
  ggplot(aes(ID, `Gas Sales`, group = 1)) +
  geom_line()
```



Data Example (cont'd)

- Convert to a time series object:

```
gas.ts <- ts(gas[2], start = c(2001, 1), frequency = 4)
gas.ts
```

```
##      Qtr1 Qtr2 Qtr3 Qtr4
## 2001  170  148  141  150
## 2002  161  137  132  158
## 2003  157  145  128  134
## 2004  160  139  130  144
```

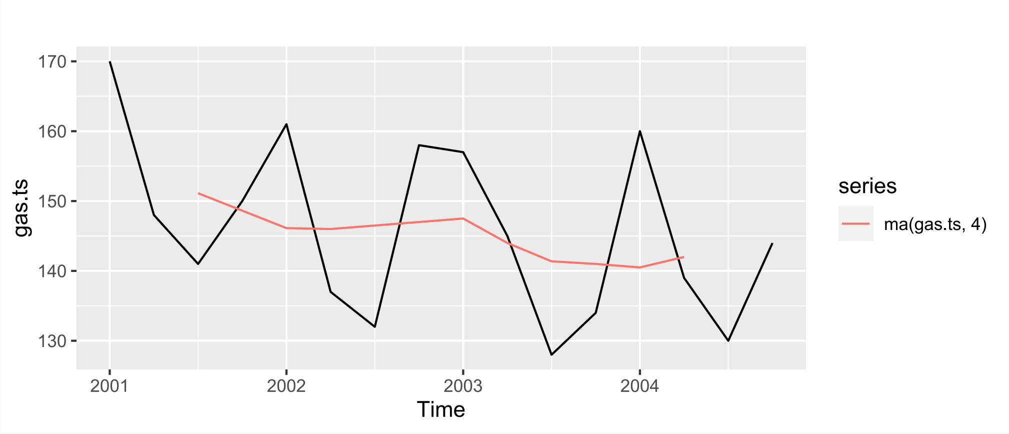
Data Example (cont'd)

- Compute and plot a moving average:

```
ma(gas.ts, 4)
```

```
##          Qtr1    Qtr2    Qtr3    Qtr4
## 2001       NA      NA 151.125 148.625
## 2002 146.125 146.000 146.500 147.000
## 2003 147.500 144.000 141.375 141.000
## 2004 140.500 142.000      NA      NA
```

```
autoplot(gas.ts) +
  autolayer(ma(gas.ts, 4))
```



Data Example (cont'd)

- Partition data to remove the last observation as test data:

```
train <- window(gas.ts, start = c(2001, 1), end = c(2004, 3))
train
```

```
##      Qtr1 Qtr2 Qtr3 Qtr4
## 2001  170  148  141  150
## 2002  161  137  132  158
## 2003  157  145  128  134
## 2004  160  139  130
```

```
test <- window(gas.ts, start = c(2004, 4), end = c(2004, 4))
test
```

```
##      Qtr4
## 2004  144
```

Data Example (cont'd)

- Use trailing MA to predict Fall 2004:

```r
ma <- forecast(rollmean(train, 4, align = "right"), h = 1)
ma
```

```
##         Point Forecast    Lo 80    Hi 80   Lo 95    Hi 95
## 2004 Q4       140.7499 137.5859 143.9139 135.911 145.5889
```

Data Example (cont'd)

- Use seasonal naive model to predict Fall 2004:

```
sn <- snaive(train, 1)
sn
```

```
##         Point Forecast    Lo 80    Hi 80    Lo 95    Hi 95
## 2004 Q4            134 121.3723 146.6277 114.6875 153.3125
```

Data Example (cont'd)

- Compare the accuracy of the two methods:

```
accuracy(ma, test)
```

```
##                      ME     RMSE      MAE        MPE     MAPE      MASE
## Training set -0.9554378 2.358523 1.836250 -0.6658609 1.269043 0.4052414
## Test set      3.2500524 3.250052 3.250052  2.2569808 2.256981 0.7172529
##                    ACF1
## Training set -0.1962972
## Test set             NA
```

```
accuracy(sn, test)
```

```
##                     ME      RMSE MAE       MPE     MAPE MASE       ACF1
## Training set -4.181818  9.853472   8 -3.122110 5.666473 1.00 -0.1788168
## Test set     10.000000 10.000000  10  6.944444 6.944444 1.25         NA
```